

Near-Zero CTE 3D Printed RoboSiC Deployable Truss Core Structures with Active Precision Adjustment, Phase I

Completed Technology Project (2018 - 2019)



Project Introduction

High-contrast (10^{-10}) imaging and spectroscopy for exoplanet science is critically dependent on telescope optics and wavefront stability. A challenging requirement on the opto-mechanical system is that of wavefront error stability on the order of 10 pm RMS per wavefront control step (~ 10 s of minutes). Goodman Technologies proposes a purposefully engineered 2nd Generation structural-grade "RoboSiC-S" to provide the degree of passive athermal stability required by the HabEX, LUVUOIR, eLISA, and LISA missions, concomitant with low areal density ($4\text{--}5\text{ kg/m}^2$) and the ability to perform active precision adjustment. The combination of 3D/AM allows the manufacture of high structural efficiency pyramidal, tetrahedral or Kagome truss sandwich core configurations, honeycomb cores, or lattice cores. Clever core design provides the additional stability benefit of cryogenic damping. RoboSiC-S, at 298K, is predicted to have 12X and 2.5X better steady state stability, respectively, than Zerodur® and M55J/954-6 (using the composites cryo-CTE). The average value of the CTE for the JWST M55J/T300/954-6 composite over the 25-150K temperature range calculated from measured Backplane Stability Test Article strains is -0.3 ppm/K (V1 tubes) and -0.125 ppm/K (spanner tubes). For comparison, RoboSiC-S has predicted a CTE of $<1\text{ ppm/K}$ from 20-180K, and near-0 CTE (0.027 ppm/K) from 20-60K. In addition to 3D/AM, electrical conductivity of RoboSiC-S allows precision threaded holes and bolts to employ a "bolt-together" approach such as was used for the composite mirror backplane of the JWST. Ultra-fine $\frac{1}{4}$ -80 bolts with 0.25mm pitch threads can be used as positioning actuators for hinged components to provide stable, athermal, and precision alignment. We plan a well-designed project to demonstrate a deployable primary mirror with backing structure, hinges, latches with stability to picometers, areal density of $4\text{--}5\text{ kg/m}^2$, and packaging efficiency of 7 deployed/stowed diameter.

Anticipated Benefits

The New Worlds Technology Development Program teams, and the various COR and PCOS STDs require affordable, low areal density and ultra-stable opto-mechanical structures. Potential NASA applications include: HabEx, LUVUOIR, eLISA Program, LISA, NASA balloon-borne missions, and multiple other missions. The mirrors and the many instruments for these missions require optical benches and ultra-stable opto-mechanical structures (hinges, latches, trusses, tubes, pins, flexures, whiffles, struts, etc.)

Non-NASA applications of low cost, lightweight, dimensionally stable mirrors and structures include space telecommunications, optical instruments/telescopes which enable imaging, surveillance, and reconnaissance missions for Department of Defense, atmospheric, agricultural and ocean resource monitoring, imagery and mapping for resource



Near-Zero CTE 3D Printed RoboSiC Deployable Truss Core Structures with Active Precision Adjustment, Phase I

Table of Contents

Project Introduction	1
Anticipated Benefits	1
Primary U.S. Work Locations and Key Partners	2
Project Transitions	2
Organizational Responsibility	2
Project Management	2
Technology Maturity (TRL)	2
Images	3
Technology Areas	3
Target Destination	3

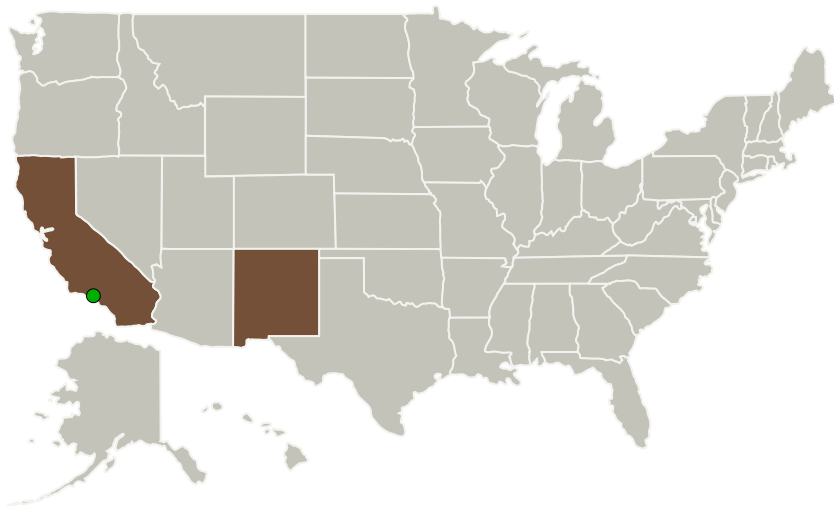
Near-Zero CTE 3D Printed RoboSiC Deployable Truss Core Structures with Active Precision Adjustment, Phase I

Completed Technology Project (2018 - 2019)



management, and disaster relief and communications. The dual-use nature applies to national defense missions such as airborne, shipborne and land-based lasers.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Goodman Technologies, LLC	Lead Organization	Industry	Albuquerque, New Mexico
● Jet Propulsion Laboratory (JPL)	Supporting Organization	NASA Center	Pasadena, California

Primary U.S. Work Locations	
California	New Mexico

Project Transitions

July 2018: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Goodman Technologies, LLC

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

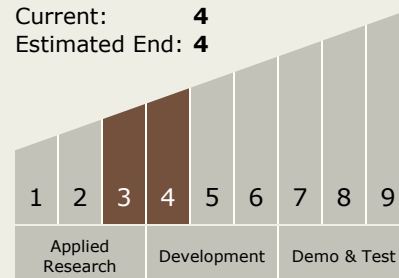
Carlos Torrez

Principal Investigator:

William Goodman

Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **4**



Near-Zero CTE 3D Printed RoboSiC Deployable Truss Core Structures with Active Precision Adjustment, Phase I

Completed Technology Project (2018 - 2019)



✓ **February 2019:** Closed out

Closeout Documentation:

- Final Summary Chart(<https://techport.nasa.gov/file/137873>)

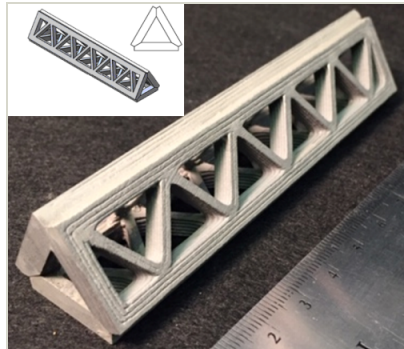
Images



Briefing Chart Image

Near-Zero CTE 3D Printed RoboSiC Deployable Truss Core Structures with Active Precision Adjustment, Phase I

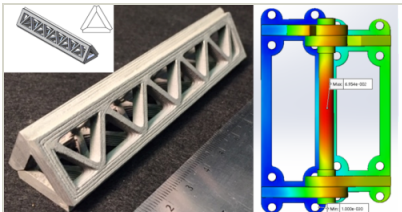
(<https://techport.nasa.gov/image/133485>)



Final Summary Chart Image

Near-Zero CTE 3D Printed RoboSiC Deployable Truss Core Structures with Active Precision Adjustment, Phase I

(<https://techport.nasa.gov/image/130783>)



	Titanium	Nitronic 60	RoboSiC Structural
Factor of Safety for Structural Loading: 2g	34	1.49×10^5	6.8×10^2
Maximum Total Displacement	5.422×10^{-1} mm	5.812×10^{-1} mm	6.954×10^{-2} mm

Final Summary Chart Image

Near-Zero CTE 3D Printed RoboSiC Deployable Truss Core Structures with Active Precision Adjustment, Phase I

(<https://techport.nasa.gov/image/134368>)

Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
 - TX12.3 Mechanical Systems
 - TX12.3.1 Deployables, Docking, and Interfaces

Target Destination

Outside the Solar System